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JUDGEMENT SPECIFICATION - A TECHNIQUE TO QUANTIFY CORPORATE SUB--ETC(U)
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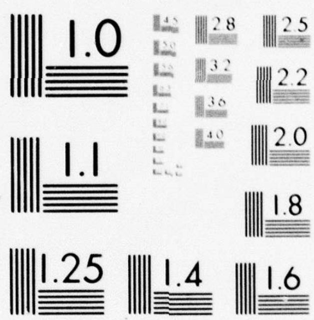


MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS 1963-A

# JUDGEMENT SPECIFICATION - A TECHNIQUE TO QUANTIFY CORPORATE SUBJECTIVITY

Technical Report

by

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December 1977



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While the contents of this report are considered to be correct, they are subject to modification upon further study. This report does not promulgate official Air Force policies or positions. The technical conclusions are solely those of the author.

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## ABSTRACT

A technique for reducing corporate judgement to a mathematical model is presented. This work is an extension of Judgement Analysis/Policy Capturing.

## INTRODUCTION

Techniques are in the literature to model on-going, corporate decision making processes (Policy Capturing) and the decision making process which may be applied to a system (Judgement Analysis). As Ward has documented (#1), the doctoral admission policies of the University of North Dakota have been successfully captured and quantified. In still another context, the decision process of the US Supreme Court has been reduced to an equation based on previous decisions in similar cases.

In application, Judgement Analysis requires the ranking of conflicting configuration of the entity or process of which a mathematical model is needed. For example, most respondents would highly desire a job which paid $40,000/annum for a standard 40 hour week. Given the choice, few would opt for $30,000/annum for the same week. However some may prefer $30k for a 30 hour week, or a 20 hour week and certainly most would opt for a 2 hour week at $30K/annum. Likewise, others may take $45K for a 50 hour week and surely most would probably jump at $150k for a 60 hour week. Judgement Analysis provides the method to find the coefficients for the equation;

$$\begin{aligned}\text{Job Desirability} = {} & A_0 + A_1 * \text{salary} + A_2 * \text{workweek} \\ & + A_3 * \text{salary}^n + A_4 \text{ workweek}^n \\ & + A5 * \text{salary} * \text{workweek} + \ldots\ldots\ldots\end{aligned}$$

There are, however, problems of magnitude in application.

Consideration of biographic data in attempting to build an enlisted procurement model led to tens of thousands of combinations of attributes. Prospective enlistees have four test scores each of which may take on 19 values, one test score in the internal of 0-100, courses taken in high school, age, number of dependents, and numerous other personal attributes. All possible combinations rapidly approaches a googol. Judgement Analysis was attempted using stochastic sampling and was not successful. This had led to an extrapolation of Judgement Analysis ... Judgement Specification.

## METHOD

To overcome the problem of magnitude generated by the enlisted procurement problem, an analysis of the process used by the "expert" respondents was initiated. (Recall that random samples were used). Typically the "expert" would select his "best" enlistee and his "worst" enlistee. Then his second best and second worst. And so forth until he exhausted his 300 candidates. This process in the absence of complete information (the other 2,700 configurations) resulted in five diverse models from five "experts". Independent interviews and then joint interviews with the respondents revealed some common trends which were probably imbedded in the diverse models. Comments such as "for a computer programming job, it doesn't matter what the man's mechnical aptitude is," or "for computer programmers, I don't care how old the man is as long as he is over 17 and under 22." And, "the last thing I want is a man who is not a high school graduate". From this it was concluded that working independently with sample data our experts agreed to disagree. But when used as a corporate consultant, it was found that the experts could accommodate one another to arrive at a mutually agreed upon threshold where they would give up a desirable attribute.

Judgement Specification then requires the brokeraging of a corporate body of experts to arrive first at the most desirable configuration of the entity to be modeled and then the order in which attributes will be given up. This manual model is then converted into a mathematical model or an equation which can be used to rank any possible configuration of the entity under consideration.

The enlistment question of computer programmers was posed to a body of five senior enlisted programmer personnel under the supervision of a moderator - "given the following attributes will be used, how would you define the best possible enlistee to be assigned as a programmer trainee?"

| AGE | AFQT | ED LEVEL | #DEPENDENTS |
|---|---|---|---|
| 17 | 30 | < High School | 0 |
| 18 | 31-40 | High School | 1 |
| 19 | 41-50 | Some College | 2 |
| 20 | : | Degree | 3 |
| 21 | 91-100 | | > 3 |
| 22 | | | |
| > 22 | | | |

| HIGH SCHOOL CURRICULUM | APTITUDE SCORES GEN | ADMIN | MECH | ELECT |
|---|---|---|---|---|
| College Preparatory | 45* | 0 | 0 | 0 |
| General | 50 | 5 | 5 | 5 |
| Vocational | 55 | 10 | 10 | 10 |
| | ⋮ | ⋮ | ⋮ | ⋮ |
| | 95 | 95 | 95 | 95 |

*minimum score of 45 required on General Airman Qualifying Exam for entry into the Air Force.

Then by a process of negotiated attrition, "how would the corporate body yield these attributes, i.e., of all of the attributes which will be given away first and how much, until all attribute values have been yielded?"

In this case, the ideal programmer trainee was defined by the attribute values listed first under each attribute shown in the table below. The Judgement Specification panel then yielded the attribute values sequentially in the order shown below:

| | AGE | | AFQT |
|---|---|---|---|
| | 19 | | 91-100 |
| 1 | 20 | 9 | 81-90 |
| 16 | 21 | 29 | 71-80 |
| 17 | 18 | 35 | 61-70 |
| 18 | 22 | 38 | 51-60 |
| 43 | >22 | 46 | < 51 |
| 44 | 17 | | |

| | ED LEVEL |
|---|---|
| | Some College |
| 15 | Degree |
| 20 | High School |
| 51 | <High School |

| | #DEPENDENTS |
|---|---|
| | 1 |
| 2 | 0 |
| 21 | 2 |
| 36 | 3 |
| 45 | >3 |

| | CURRICULUM |
|---|---|
| | College Preparatory |
| 30 | General |
| 37 | Vocational |

APTITUDE SCORES

| | GEN | | ADM | | MECH | | ELECT |
|---|---|---|---|---|---|---|---|
| | 95 | | 95 | | 95 | | 95 |
| 12 | 90 | 10 | 90 | 3 | 90 | 13 | 90 |
| 19 | 85 | 11 | 85 | 4 | 85 | 22 | 85 |
| 23 | 80 | 14 | 80 | 5 | 80 | 24 | 80 |
| 27 | 75 | 25 | 75 | 6 | 75 | 28 | 75 |
| 33 | 70 | 26 | 70 | 7 | 70 | 34 | 70 |
| 40 | 65 | 32 | 65 | 8 | 65 | 41 | 65 |
| 49 | 60* | 39 | 60 | 31 | 60 | 46 | 60 |
| | | 47 | <60 | 42 | <60 | 50 | <60 |

*Mandatory minimum to enter programming career field.

These numbers were then transformed to reflect the relative weight attached to the individual attributes and the relationship within each attribute. This was done by assigning the highest ordinal value at which yielded, to the most desirable value in the attribute column and employing the delta at each step thereafter to generate the remaining values. The following

payoff coefficients resulted:

| AGE | AFQT | ED LEVEL | #DEPENDENTS |
|---|---|---|---|
| 19:44 | 91-100:46 | Some College: 51 | 1:45 |
| 20:43 | 81-90:37 | Degree: 36 | 0:43 |
| 21:28 | 71-80:17 | High School: 31 | 2:24 |
| 18:27 | 61-70:11 | <High School: 0 | 3:9 |
| 22:26 | 51-60:8 | | >3:0 |
| >22:1 | <51:0 | | |
| 17:0 | | | |

| CURRICULUM | APTITUDE SCORES | | | |
|---|---|---|---|---|
| | GEN | ADM | MECH | ELECT |
| College Prepatory: 37 | 95:49 | 95:47 | 95:42 | 95:50 |
| General: 7 | 90:37 | 90:37 | 90:39 | 90:38 |
| Vocational: 0 | 85:30 | 85:36 | 85:38 | 85:29 |
| | 80:26 | 80:33 | 80:37 | 80:27 |
| | 75:22 | 75:22 | 75:36 | 75:23 |
| | 70:16 | 70:21 | 70:35 | 70:17 |
| | 65:9 | 65:15 | 65:34 | 65:9 |
| | 60:0 | 60:8 | 60:11 | 60:2 |
| | | <60:0 | <60:0 | <60:0 |

The above produces a mutually exclusive categorical model which returns payoffs in the interval of 0-to-411. This score may be converted to any convenient interval, say 0-to-100, to arrive at tradeoffs with other similar equations with which the enlistee will be scored.

RESULTS

Three predictive techniques were used to identify successful airmen where "success" was defined as achieving paygrade E-5 (Staff Sergeant) in less than the median time of 55.5 months. These methods were: 1. Multivariate Regression, 2. Odds for Effectiveness and 3. Judgement Specification. The results of this investigation were documented in DPMDDA Memorandum, "PROMIS Person-Job-Match Algorithm Predicting Job Success", dated 30 March 1976, which is included as Appendix A. This memorandum concluded, " . . . the predictive equations derived from the three methods provide similar degrees of accuracy with regression and Odds for Effectiveness being slightly better than Judgement Specification. One would thus conclude that the decision on which technique to employ would have to be made on considerations other than predictive accuracy (i.e. cost)."

## CONCLUSION

Judgement Specification is the indicated technique when numerous attributes/values must be included. For example, the programmer trainee discussed above could be defined in 14,696,640 different configurations. Not feasible in Judgement Analysis. The process is much faster, simpler and cheaper than the attendent "card sorting" involved in Judgement Analysis. Further, all expert respondents will understand the process and will be forced to consider the relative worth of every attribute value resulting in one brokered equation for the panel of experts. Finally, the Judgement Specifiaction Technique will provide a non-linear model without the additional cost of model seeking.

Drawbacks, however, do exist. Without a doubt the model will be extremely sensitive to which experts comprise the panel. Also, it is probable that a persuasive or weak moderator could bias the model, or possibly a "natural-born" leader on the panel could subvert the model to reflect "his" model of the process under study.

# REFERENCES

1. Ward, Joe H. Jr., Analyzing Judgement and Decision Processes (Southwest Educational Development Laboratory, October 1970).

MEMORANDUM

PROMIS PERSON-JOB-MATCH ALGORITHM

PREDICTING JOB SUCCESS

SUMMARY & CONCLUSIONS OF DEVELOPMENT TO DATE

1. ODDS FOR EFFECTIVENESS - This technique is especially useful in developing prediction equations when the dependent variable to be predicted is dichotomous in nature (e.g. pass/fail, attrit/continue, etc.). The procedure consists of (a) collecting an historical data base containing predictive attributes and the value of the dichotomous dependent variable (usually coded 0 or 1) for each individual in the data base; (b) defining a series of categories of individuals based on predictive attribute values (c) computing, for each category, the proportion of individuals in that category who have a particular value of the dependent variable (the proportion thus computed for each category then becomes the predicted probability, or odds that an individual whose attributes place him in that category will take on the particular value of the dichotomous dependent variable). (d) multiple linear regression is then used to convert the Odds for Effectiveness table to a single equation in which an individual's attribute values are used to compute his predicted odds.

2. APPLICATION TO PROMIS - In previous studies we had selected time for promotion to Staff Sergeant (E-5) as a measure of job success and attempted to run regression to predict when an individual would make E-5. Like the HRL regression studies

(to predict and individual's grade in Tech School) we obtained very low R-squared values (on the order of .15). Using the same data base (E-5's currently serving in the 702XX specialty who entered the Air Force since 1966, were not cross trainees or prior service) we applied the Odds for Effectiveness technique by creating a dichotomous dependent variable in which an "effective" airman was defined as one who was promoted to E-5 in less than the median time of 55.5 months (coded 1). The categories were then constructed and each airman in the data base was placed in a category based on his attributes. The probability of making E-5 in less than 55.5 months (i.e. being "effective"), was then computed for each category. This information was then put into equation form by running regression; the resulting equation had a very impressive R-squared value of approximately .9.

3. TESTING - At this point in our analysis we had three techniques, each of which proported to predict job success in the 702XX specialty:

a. REGRESSION - Essentially the same technique employed by HRL; very low R-squared.

b. JUDGEMENT SPECIFICATION - The quantified judgement of five senior people with much experience in the 702XX specialty.

c. ODDS FOR EFFECTIVENESS - Same data used as the regression technique but high R-squared.

To evaluate these equations the following scheme was employed:

a. Of the overall data records available, 80% were selected at random (about 2600 records) for use in constructing the re-

gression and Odds for Effectiveness equations (the Judgement Specification equation is not based on historical data).

b. The remaining 20% of the data (about 700 records) was used to test the predictive accuracy of the equations.

c. Each record in the test data base was scored by each of the three equations.

d. Each record in the test data base was then evaluated as being a "success" or "failure" based on when the individual was promoted to E-5 (below or above the median).

e. A series of cut scores (or critical values) were then selected for each of the equations. The cut score provided an arbitrary definition of predicted "success" (i.e. if the computed score is equal to or greater than the cut score, the record is predicted to be a "success").

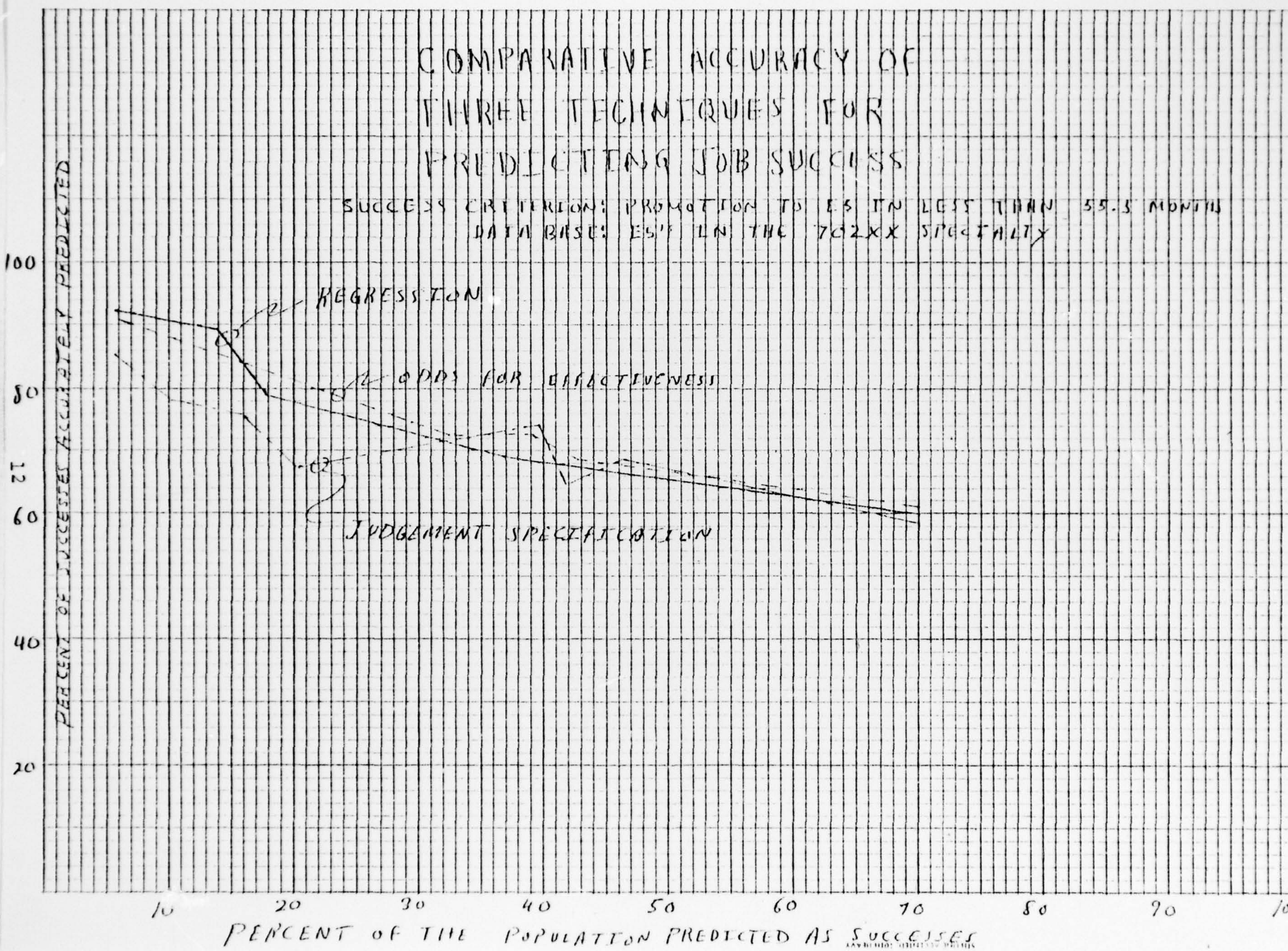
f. For each cut score for each equation two percentages were computed: The percent of the test data predicted to be successes; and the percent of the predicted successes who are actually successes (measure of accuracy).

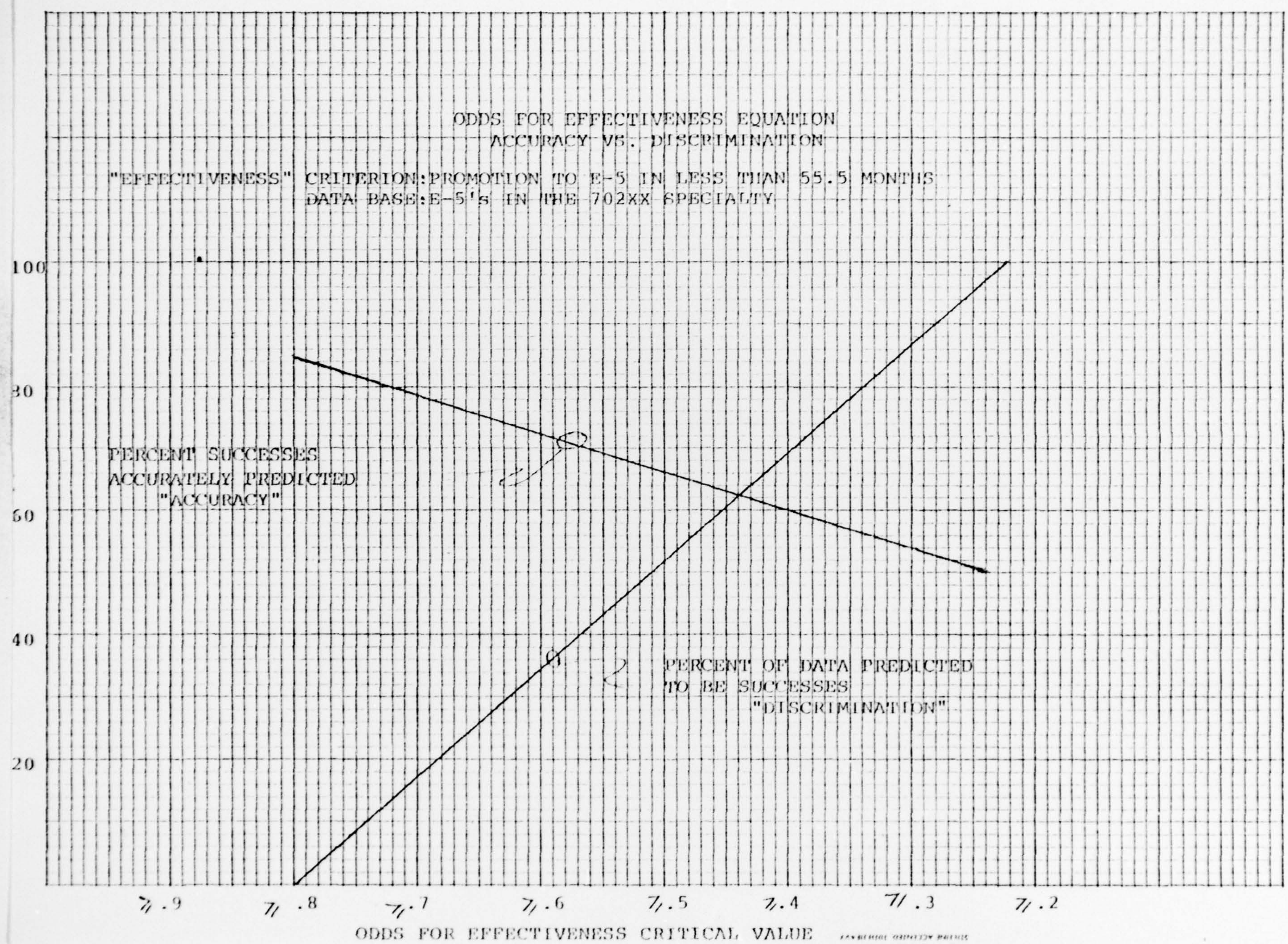
g. These two percentages were then plotted for each cut score for each of the three equations being evaluated (See Figure 1).

h. Figure 2 is a graphical representation of the relationship between critical value, percent predicted success, and percent accuracy for the Odds for Effectiveness equation as applied to the test data base.

4. CONCLUSIONS - Figure 1 shows that the predictive equations derived from all three techniques provide very similar degrees of accuracy with regression and Odds for Effectiveness being slightly better than Judgement Specification. One would thus conclude that the decision on whcih technique to employ would have to be made on considerations other than predictive accuracy (i.e. cost).

5. RECOMMENDATION - Since HRL has already begun development of job success predicting equations using the regression technique, it would not be cost effective to pursue Judgement Specification or Odds for Effectiveness any further for application to PROMIS.


COMPARATIVE ACCURACY OF
THREE TECHNIQUES FOR
PREDICTING JOB SUCCESS
SUCCESS CRITERION: PROMOTION TO E5 IN LESS THAN 55.5 MONTHS
DATA BASE: E5'S IN THE 702XX SPECIALTY
REGRESSION
ODDS FOR EFFECTIVENESS
JUDGEMENT SPECIFICATION
PERCENT OF SUCCESSES ACCURATELY PREDICTED
100
80
60
40
20
10
20
30
40
50
60
70
80
90
100
PERCENT OF THE POPULATION PREDICTED AS SUCCESSES



ODDS FOR EFFECTIVENESS EQUATION
ACCURACY VS. DISCRIMINATION
"EFFECTIVENESS" CRITERION:PROMOTION TO E-5 IN LESS THAN 55.5 MONTHS
DATA BASE:E-5's IN THE 702XX SPECIALTY
100
80
60
40
20
PERCENT SUCCESSES
ACCURATELY PREDICTED
"ACCURACY"
PERCENT OF DATA PREDICTED
TO BE SUCCESSES
"DISCRIMINATION"
1 2
7/ .9
7/ .8
7/ .7
7/ .6
7/ .5
7/ .4
7/ .3
7/ .2
ODDS FOR EFFECTIVENESS CRITICAL VALUE